November 5, 2002

Offerors:

Subject: Amendment No. 3 to Request for Proposal No. RAM-2-32246 for Computational Aeroacoustic Analysis of Wind Turbines

The following lists questions submitted and answers provided to those questions to date:

1. Is this RFP mainly directed at the large scale wind turbines or the smaller wind turbines. The frequencies/scales etc. are very different for the two types of machines and thus may actually need to be computed using different methodologies. Along the same lines: is it directed at wind farms or single wind turbines?

   Answer:

   DOE and NREL are interested in both large wind turbines (for bulk power generation) and small wind turbines (for distributed generation). Many of the aeroacoustic design challenges are the same for both, namely quiet airfoils, quiet blade tip shapes, and operation in turbulent inflow. An offeror may choose to address small wind turbines, large wind turbines, or both depending upon their interest, expertise, assessment of the resources required to address the problems, and the likelihood of success in achieving project objectives. NREL's primary interest is in the aeroacoustic modeling of stand-alone wind turbines and their important components, such as airfoils and blade tips.

   The impact of wind farms on acoustic emissions is most likely to result from the complex, turbulent inflow experienced by turbines in these arrays. Considerable effort has been expended over the years in developing turbulent inflow models. If appropriate, NREL will assist subcontractors in identifying and using these models. Therefore, it is desired that any computational aeroacoustic analyses would be capable of reflecting the impact of different inflow conditions.

2. Has NREL already determined that the Gutin noise (moving thickness source) is not important?

   Answer:

   NREL has not made any determination about the importance of this source.

3. What is the (i) Blade tip velocities, (ii) blade aspect ratio, (iii) blade planform, (iv) blade tip speed, (v) blade twist, (vi) blade thickness for both the large and the small wind turbines, and (vii) blade radius for both the large and the small wind turbines?

Answers:

- Maximum blade tip velocities are in the range of 60-80 m/s. Some variable speed turbines operate at very low tip velocities of approximately 20 m/s at low wind speeds.
- Blade aspect ratios are typically in the range of 20-35.
- Blade taper ratios are typically in the range of 0.3 to 0.4.
- Blade twist varies from by manufacturer, but the typical range is 12-20 degrees.
- Airfoil thickness (as a percentage of chord) is typically 10-15 % in the outboard sections of a blade. In the root area the thickness ratio is typically 20-30%, although some small wind turbines are of constant cross section.
- Typical diameters for small wind turbines are in the range of 1-15 meters. Large turbines have diameters in the range of 40-90 meters.

4. Atmospheric conditions (e.g. height above sea level and above ground)?
5. Reynolds numbers for the large and small wind turbines?
6. Inflow turbulence conditions?
7. Vertical variation in wind velocities over the turbine blade disc plane?

Answers:

- Wind turbines are typically sited from sea level to approximately 2,000 meters.
- Small turbines operate at Reynolds numbers in the range of 100,000 to 1,000,000. Large turbines operate at Reynolds numbers in the range of 4-6 million.
- It is extremely difficult to broadly categorize inflow turbulence. For structural loads calculations, inflow turbulence intensities of 0.10 to 0.20 are typical. Many other issues come into play, however, such as turbulence scale, atmospheric stability, vertical and horizontal wind shear. Detailed information will be made available as the research proceeds.
- For energy capture and loads calculations, a vertical wind shear value of 0.14 is typically used. However, measurements have shown that values of 0.20 are not uncommon.

8. What does "furling" mean? Is this related to vortex roll-up?

Answer:

- The term "furling" refers to small wind turbines with tail vanes. The yaw axis of the turbine is offset from the thrust axis of the rotor, and the tail is hinged. At low wind speeds, the tail vane has the effect of aligning the rotor axis of rotation with the incoming wind. At high wind speeds, the turbine nacelle (and thus, the rotor plane of rotation) moves away from the incoming wind as a result of the offset of the thrust vector. Thus, the relative inflow velocity decreases and the lift- and torque-producing forces are reduced. "Furling" is essentially a power regulation mechanism. Some turbines employ vertical furling, but the principle is the same as horizontal furling. Unfortunately, furling produces dramatically unsteady aerodynamic and structural forces, and typically, large amplitude broadband acoustic emissions.

9. What is the anticipated start date for Phase I?

Answer: Approximately April or May of 2003.

10. What is the funding limit for Phase I?

    Answer: There is no specified limit for Phase I.

11. If proprietary (off the shelf) codes are involved in the CAA solutions are these expected in task 5 and deliverable #3, or will NREL acquire these separately?

    It is expected that the codes will be delivered to NREL. Any special intellectual property provisions will be negotiated as needed and on a per contract basis.

The due date for submittal of proposals remains unchanged (11/25/02).

Neil Wikstrom
Contract Administrator